ACETABULAR FRACTURES CLASSIFICATION OF LETOURNEL AND JUDET— A SYSTEMATIC APPROACH

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INTRODUCTION

The acetabulum is a complex structure and fractures in this region can be difficult to classify radiographically. In clinical practice and research the classification method of Judet and Letournel is most widely used. We found a significant learning curve associated with classifying these fractures using this method. Accurate classification of every case requires an experienced observer and prolonged study of excellent x-rays. Thus, we developed a systematic approach by which the inexperienced observer can learn to recognize fracture patterns in the majority of cases. This approach is intended as an aid to understanding a well accepted classification which will shorten the

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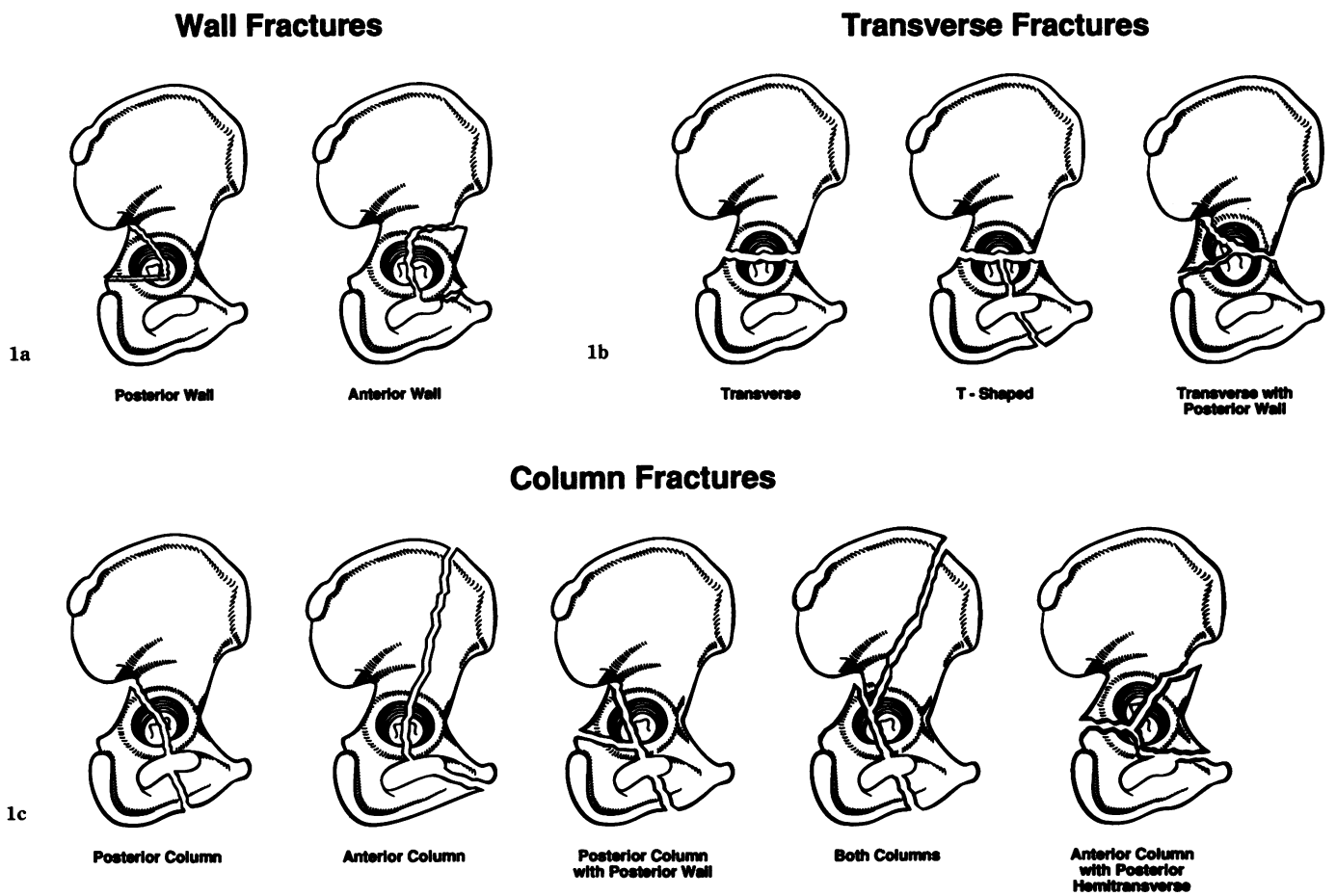

Figure 1a-c
Drawings demonstrating the acetabular fracture patterns as described by Judet and Letournel. They are grouped into wall fractures (1a), transverse fractures (1b), and column fractures (1c). (Reprinted, with permission, from: Acetabular Fractures: A Systematic Approach to Classification. Journal of Emergency Radiology, Jan/Feb 1995.)

learning curve associated with classifying these fractures by the method of Judet and Letournel.

I. JUDET AND LETOURNEL CLASSIFICATION

The anatomic classification of acetabular fractures was established by Judet in 1964 and was slightly modified by Letournel. This classification was developed prior to computed tomography and was based on A/P and oblique x-rays. Ten fracture patterns were divided into two groups consisting of five elementary and five associated fracture types. We propose regrouping these into three primary fracture patterns: Wall, Transverse, and Column, each with unique recognizable radiographic features (Fig. 1a,b,c).

II. ANATOMY

Skeletal anatomy

Understanding the columns of the acetabulum is critical to accurately use this fracture classification. From its lateral aspect, the acetabulum forms an inverted Y, one limb forming the anterior column and one the posterior column[2] (Figure 2). The anterior column is the anterior and superior portion of the hemipelvis. It extends from the iliac crest to the symphysis pubis and includes the anterior wall of the acetabulum. Think of it as the portion of a brittle model that would break from a twist to the anterior superior iliac spine and anterior wall of the acetabulum. The posterior column is the posterior and inferior portion of the acetabulum. It begins at the superior gluteal notch and descends through the acetabulum, obturator foramen, and inferior pubic ramus and includes the posterior wall of the acetabulum, ischial spine and ischial tuberosity. Think of it as the portion of a brittle model that would break from a twist to the ischial tuberosity and posterior wall of the acetabulum.

Radiographic Landmarks

Three radiographic views should be obtained to evaluate acetabular fractures. These are the anteroposterior (AP) and two 45° oblique Judet views (obturator oblique (OO) and iliac oblique (IO)) (Figure 3a,b,c). The AP radiograph

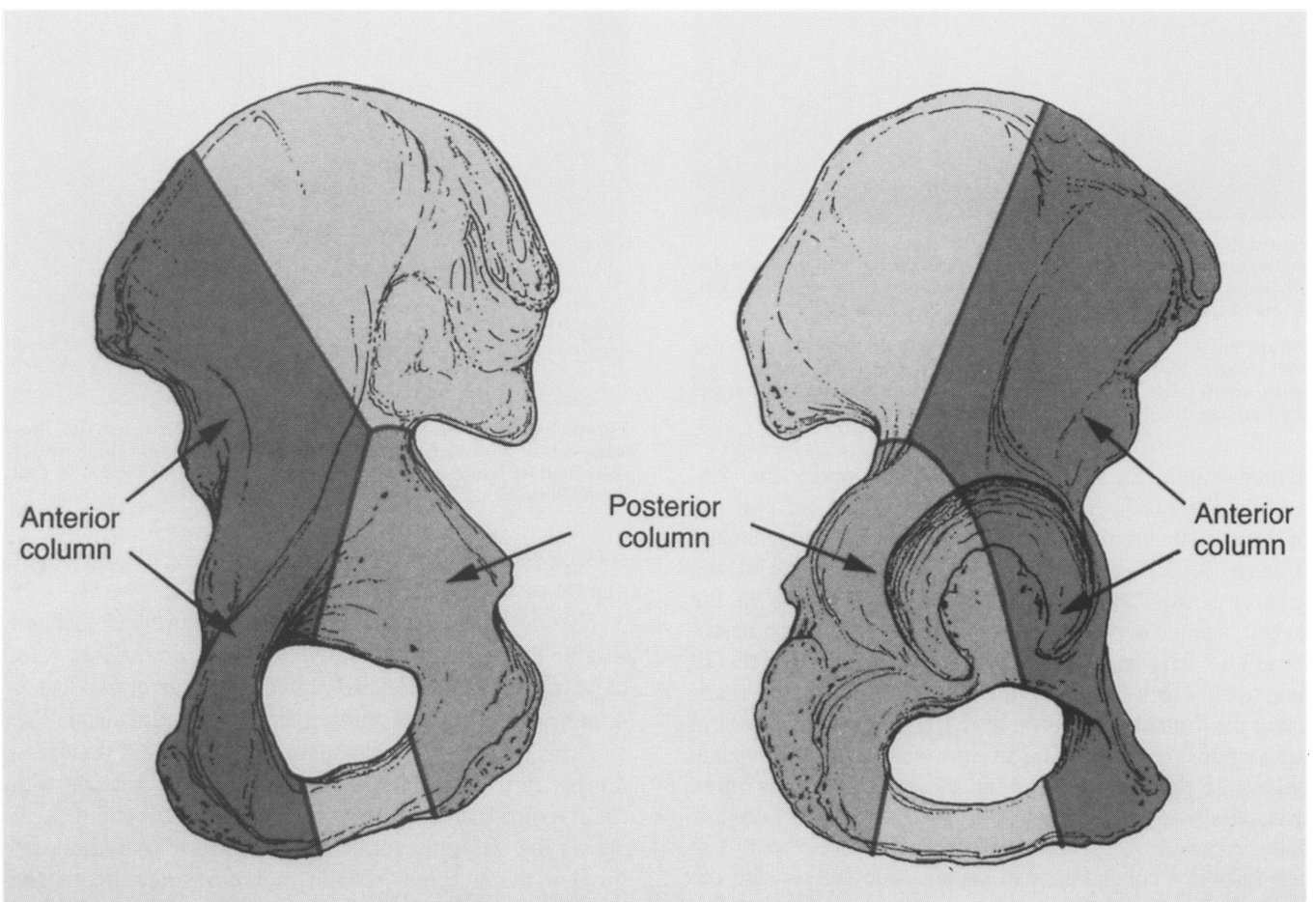

Figure 2 Drawing demonstrating the extent of the anterior and posterior columns on the inner and outer aspects of the bone. (Reprinted, with permission, from: Browner, Jupiter et al: Skeletal Trauma, Vol 2, p.900. Philadelphia, W.B. Saunders, 1992.) Note that the anterior column is mostly superior, and the posterior column is mostly inferior.

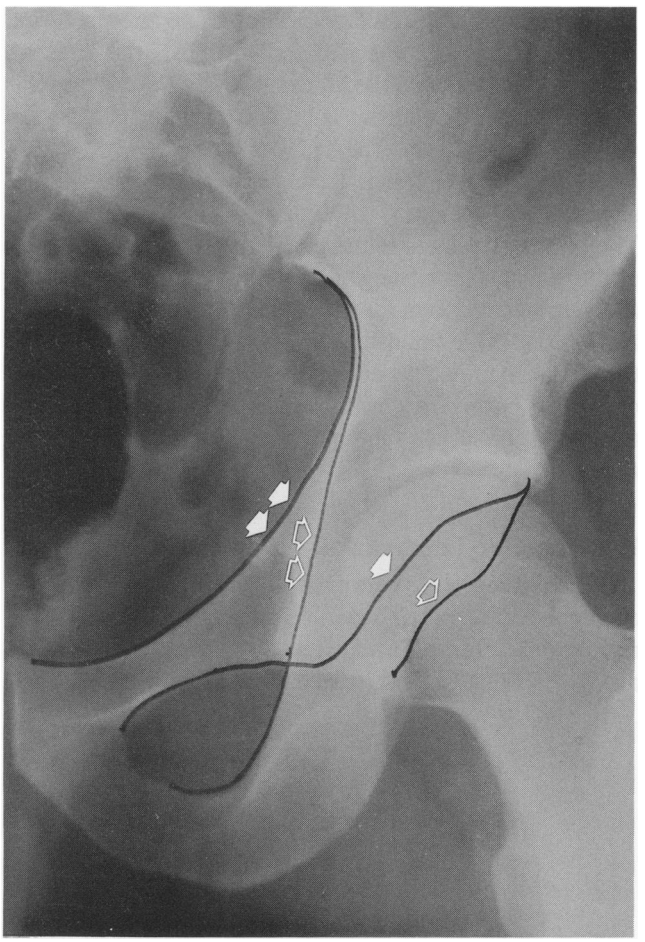

Figure 3a-g
Radiographs and CT cuts demonstrating the normal radiographic landmarks of the acetabulum. These three radiographs and four levels of CT cuts should be examined in each case.

Figure 3-a On the anteroposterior radiograph, note the posterior wall (single, hollow white arrow), the anterior wall (single, solid white arrow), the iliopectineal line (double, solid white arrows) and the ilioischial line (double, hollow white arrows).

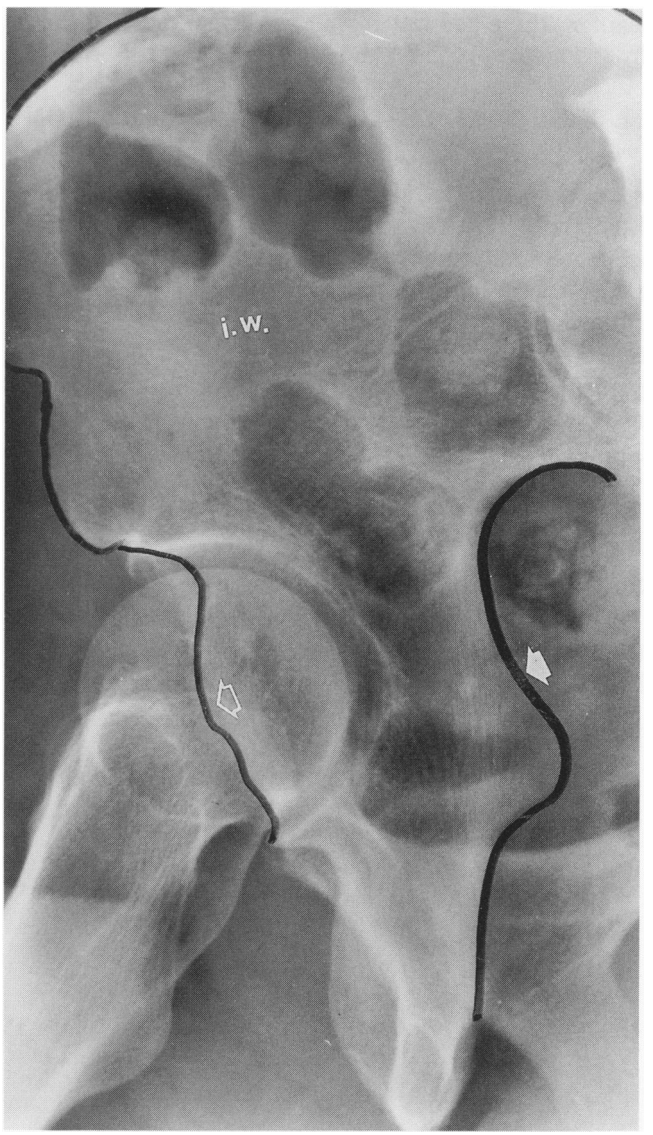

Figure 3-b The iliac oblique radiograph demonstrates the iliac wing (i.w.), posterior column (solid white arrow) and the anterior wall (hollow white arrow). The superior portion of the PC is well demonstrated.

demonstrates the following four landmarks: the iliopectineal line (IP), the ilioischial line (II), the anterior rim of the acetabulum, and the posterior rim of the acetabulum (Figure 3a). The boundary of the II line starts at the greater sciatic notch and runs along the course of the ischial spine to the posterior border of the obturator foramen.[1] The line usually begins proximally with the IP line, with which it appears to blend. The IP line extends along the "radiologic" pelvic brim to the superior border of the symphysis pubis.[1] The anterior wall of the acetabulum begins at the external border of the roof but is more horizontally oriented than the posterior border and is superimposed on the shadow of the posterior wall. The line follows a curved path to become continuous with the superior border of the obturator foramen. The posterior wall is visualized as a straight line that is continuous superiorly with the beginning of the outline of the articular surface and inferiorly overlies the outline of the upper margin of the ischial tuberosity.

The 45° IO view is taken with the fractured acetabulum rotated away from the x-ray tube. It shows the iliac wing in its largest dimension and profiles the greater and lesser sciatic notches and the anterior rim of the acetabulum. The superior portion of the posterior column is best visualized on this view (Figure 3b). The 45° OO view is taken with the fractured acetabulum rotated toward the x-ray tube. It shows the obturator foramen in its largest dimension and profiles the anterior column and posterior rim of the acetabulum. The inferior portion of the anterior column is best seen on this view (Figure 3c). For maximal information full 45° oblique views are necessary (on the OO, the tip of the coccyx should be over the femoral head).

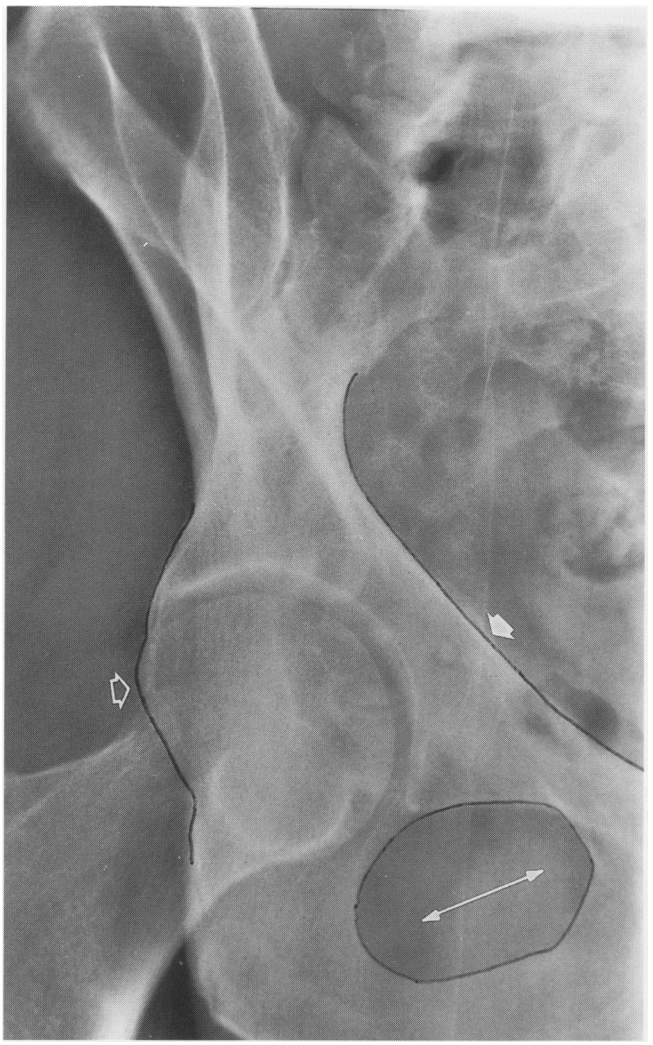

Figure 3-c The obturator oblique radiograph demonstrates the obturator ring (double-headed arrow), the anterior column (solid white arrow), and the posterior wall (hollow white arrow). It demonstrates the inferior portion of the anterior column. Scrutinize this view for breaks into the obturator ring.

Computed Tomography

Computed tomography (CT) is useful for evaluating the orientation of the main fracture line (transverse vs column), the location and size of wall fractures and for evidence of marginal impaction around major fracture lines. In addition, it can be used as an aid to accurate fracture classification. An axial CT will conclusively determine the presence or absence of an anterior column fracture into the iliac wing and the presence or absence of a break in the obturator ring indicating a T- type or column fracture. Familiarity with axial CT sections through the pelvis and acetabulum is required to obtain this information.

Study the axial CT cuts in four locations: the iliac wing, the superior dome, through the acetabulum at the level of the anterior and posterior walls, and at the level of the

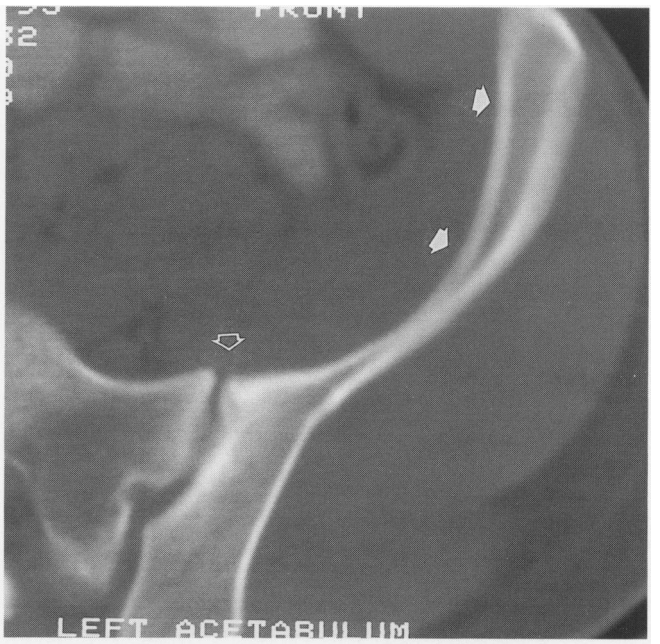

Figure 3-d This proximal CT cut at the level of the SI joint will show a fracture of the AC. Note the SI joint (hollow white arrow) and the iliac wing (solid white arrows).

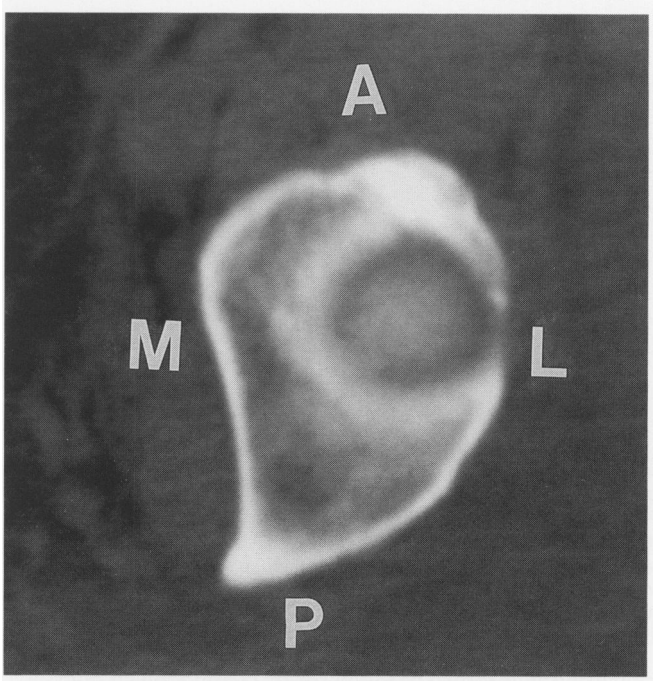

Figure 3-e An axial CT cut at the level of the dome. Note the anterior, posterior, medial and lateral borders of the acetabular dome.

inferior acetabulum near the entrance to the obturator ring. The iliac wing should be seen from the ASIS to the SI joint (Figure 3d). The presence of a fracture line in this area indicates a fracture of the anterior column and the absence of a fracture usually means that there is not an anterior column fracture; an exception to this would be an

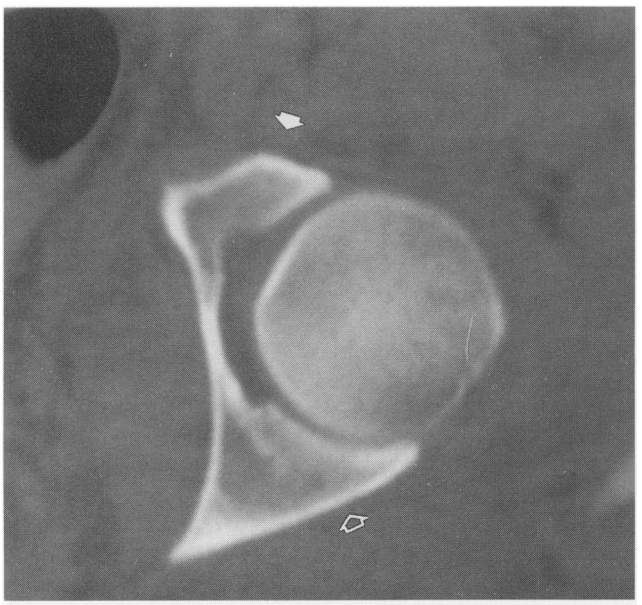

Figure 3-f Further caudally, note the anterior (solid white arrow) and posterior (hollow white arrow) walls. This CT cut is at the mid-level of the joint.

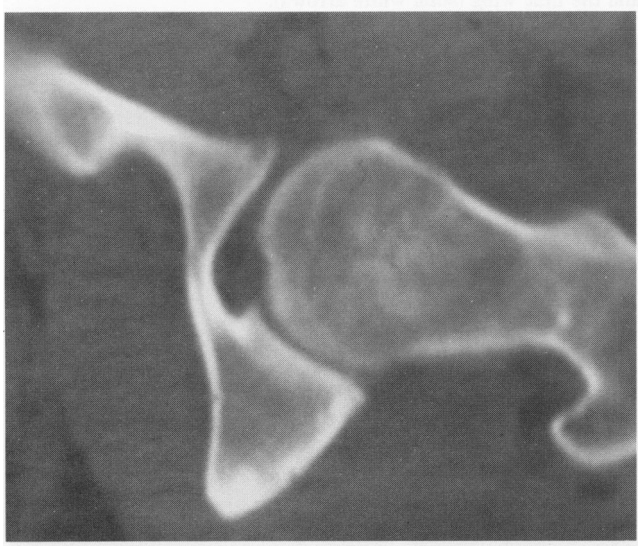

Figure 3-g The inferior portion of the acetabulum just before entering the obturator ring is visualized on this cut. A break in the quadrilateral plate at this level indicates a fracture extending into the obturator ring.

unusual low fracture of the anterior column which does not reach this level. The superior dome has a typical appearance with anterior, posterior, medial and lateral borders (Figure 3e). A fracture line from anterior to posterior in this region indicates a transverse fracture pattern. A medial to lateral fracture line indicates a column fracture pattern. Evaluate the anterior and posterior walls at the level of the middle of the joint (Figure 3f). Finally, the inferior acetabulum, just before the entrance to the obturator ring, should be evaluated for a fracture in the quadrilateral plate at this level (Figure 3g). The presence

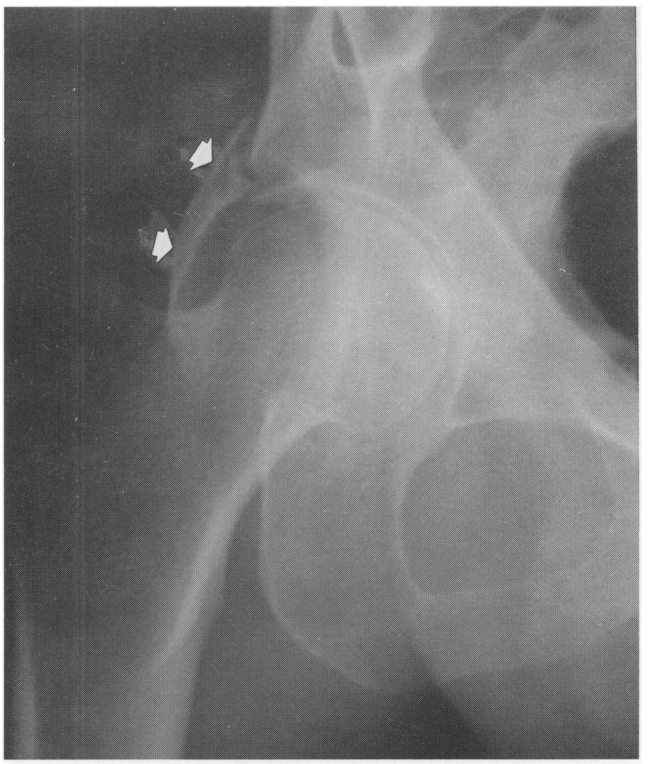

Figure 4a-b Radiographs and CT of a posterior wall fracture. Figure 4-a Posterior wall fracture can be seen on the obturator oblique (solid white arrows).

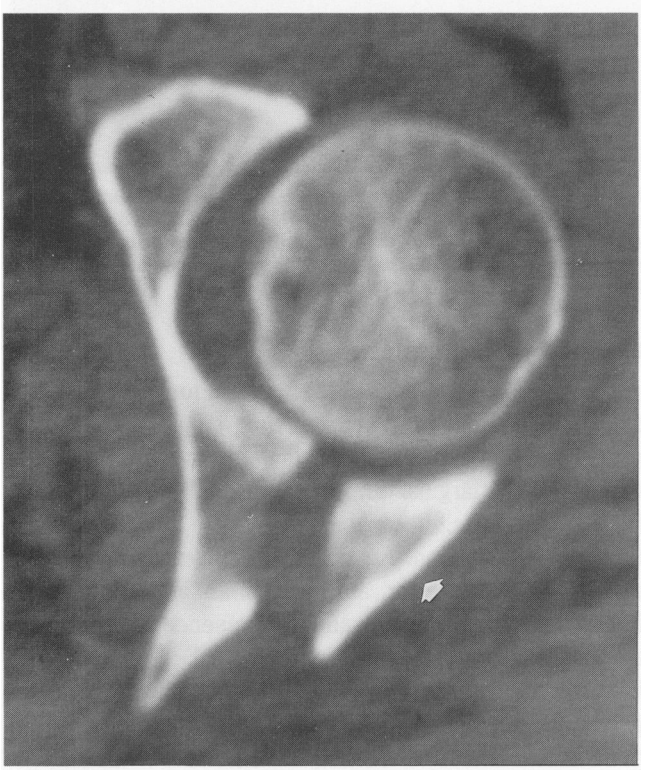

Figure 4-b The CT scan through the joint demonstrates the large posterior wall fragment (white arrow).

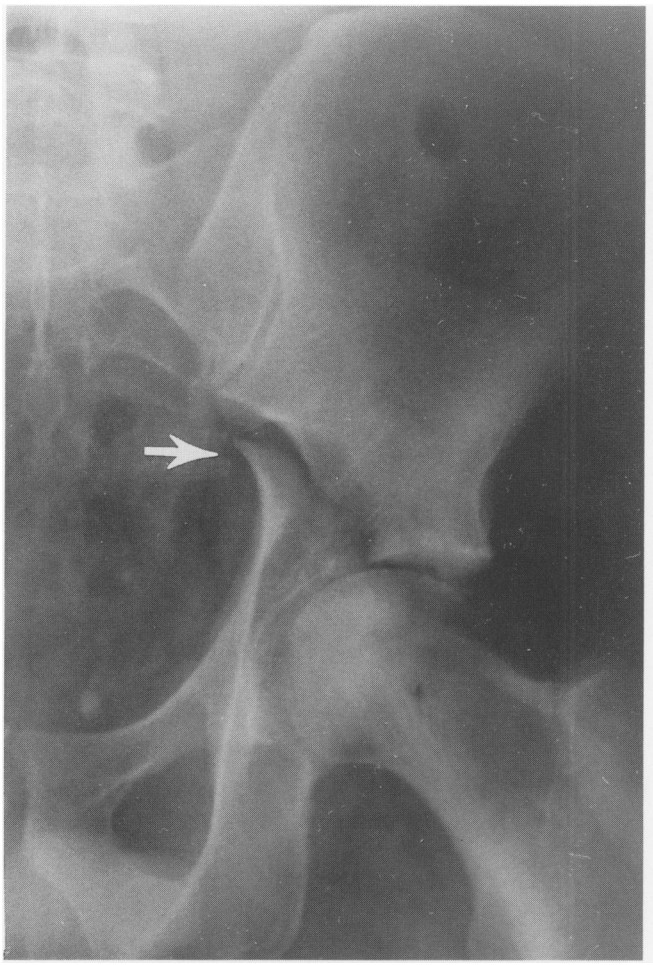

Figure 5a-b Radiographs and CT of a displaced transverse acetabular fracture.

Figure 5-a A moderately displaced transverse fracture is seen on the AP radiograph. Note the disruption of the IP and II lines (large white arrow). The obturator ring is intact (this would be checked on the OO and CT at the inferior acetabulum), eliminating a T-type fracture pattern.

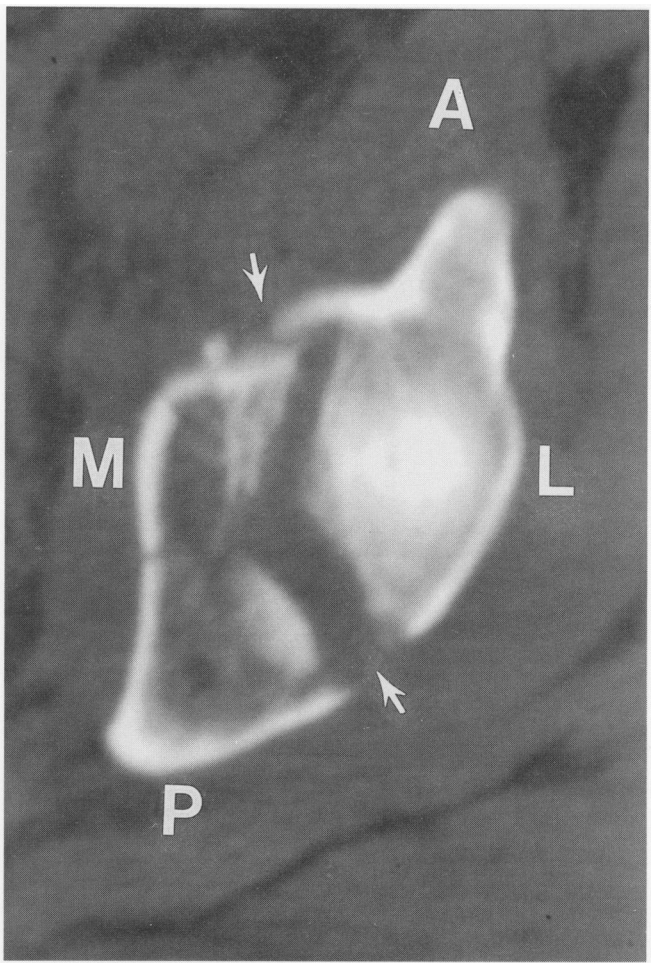

Figure 5-b Note the classic anterior to posterior fracture pattern on the CT cut through the dome (white arrows), indicating a transverse fracture rather than column fracture.

of a fracture here indicates a column fracture pattern (most commonly posterior column) or a T-shaped transverse fracture.

III. THE THREE BASIC PATTERNS

Wall fractures

Posterior wall fractures are extremely common and anterior wall fractures are extremely rare. In the large series of acetabular fractures presented by Letournel, anterior wall fractures comprised only 1.9% of all fracture types.[1] Therefore, we will concentrate on the identification of the posterior wall fracture. Posterior wall fractures are best seen on the OO view (Figure 4a) and on the CT through the level of the center of the joint (Figure 4b). This shows the typical appearance of a posterior wall fracture. Learn to recognize it because it frequently occurs in association with other patterns. If isolated, the II and IP lines should not have crossing fracture lines, the obturator ring should not be broken and there should not be a fracture into the iliac wing. The presence of any of these findings indicates that the posterior wall is associated with another pattern.

Transverse

Transverse fractures divide the acetabulum into a top and bottom half (Figure 5a). The fracture line runs from the front to the back of the pelvis through the acetabulum. The ilioischial and iliopectineal lines will be disrupted. *Note that disruption of these lines therefore does not necessarily imply a column fracture pattern.* The iliac wing is intact and part of the weight bearing dome remains intact with the proximal hemipelvis. Since the fracture line runs from anterior to posterior the CT scan will frequently demonstrate an anterior to posterior fracture line through the dome (Figure 5b). The obturator ring will be fractured

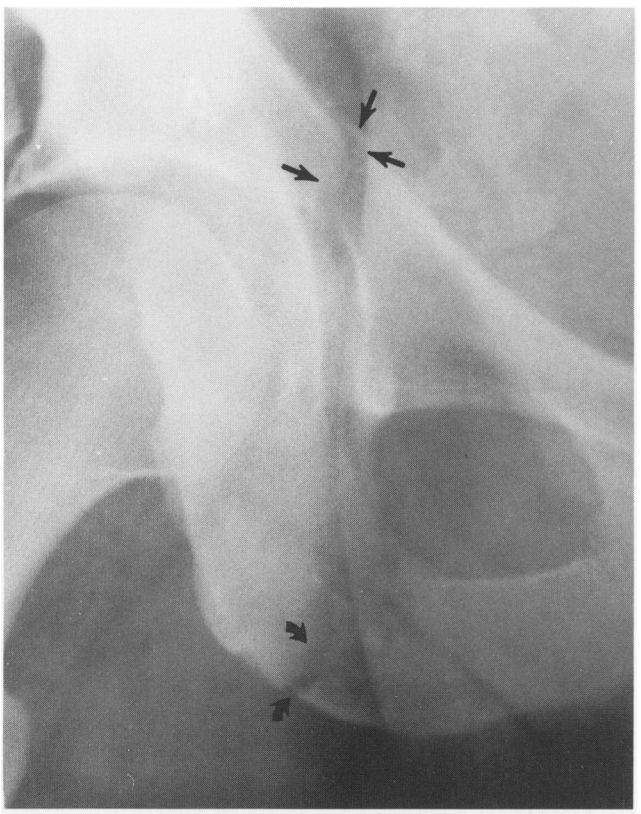

Figure 6a-d Radiographs and CT's of a T-shaped acetabular fracture.

Figure 6a The AP pelvis film suggests disruptions of both the II and IP lines (narrow black arrows) and a break in the inferior portion of the obturator ring (wider curved black arrows).

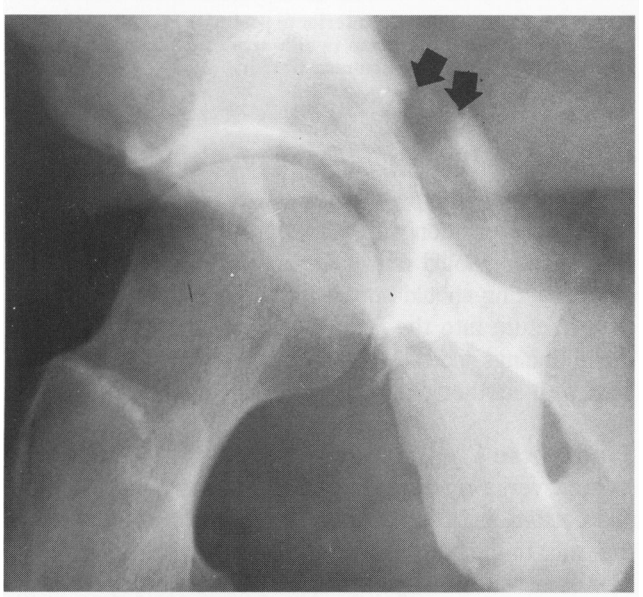

Figure 6b The IO confirms a posterior fracture (black arrows).

only in the transverse variant called the T-type fracture (Figure 6a,b,c,d). There are three fracture types that demonstrate an underlying transverse pattern. These

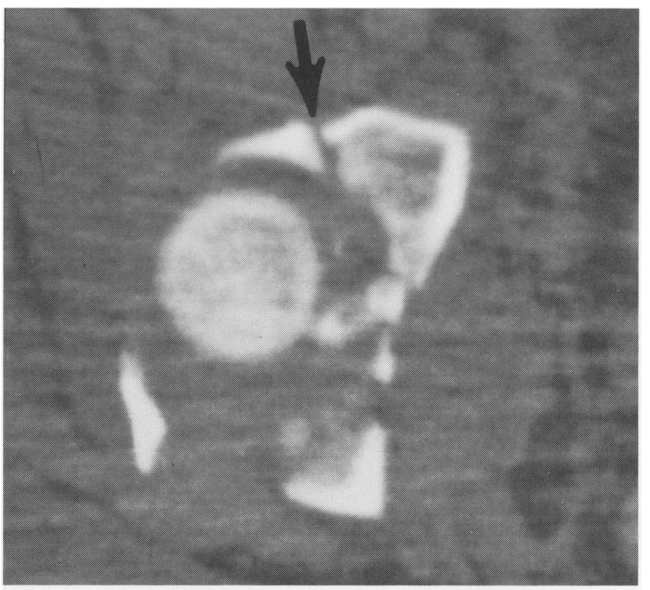

Figure 6c The CT cut near the dome shows an anterior fracture line (black arrow) and suggests a general anterior to posterior fracture configuration, indicating a transverse pattern.

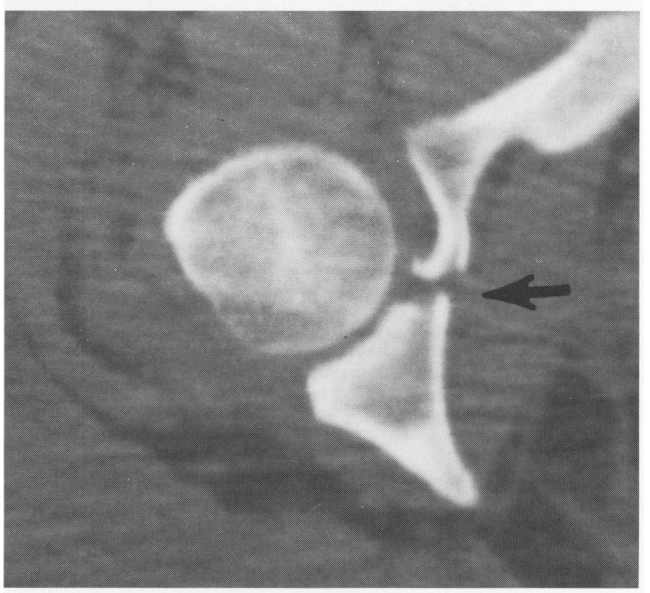

Figure 6d The CT at the inferior acetabulum confirms a quadrilateral plate fracture into the obturator ring.

include simple transverse (Figure 5a,b), transverse with posterior wall, and the T-type fracture (Figure 6a,b,c,d). In the T-type the bottom half of the transverse is split by a longitudinal fracture line dividing the obturator ring. Look for a fracture into the obturator ring on the OO radiograph and on the CT at the inferior acetabulum just before entering the ring. The transverse posterior wall is a posterior wall fracture associated with the other features of a transverse.

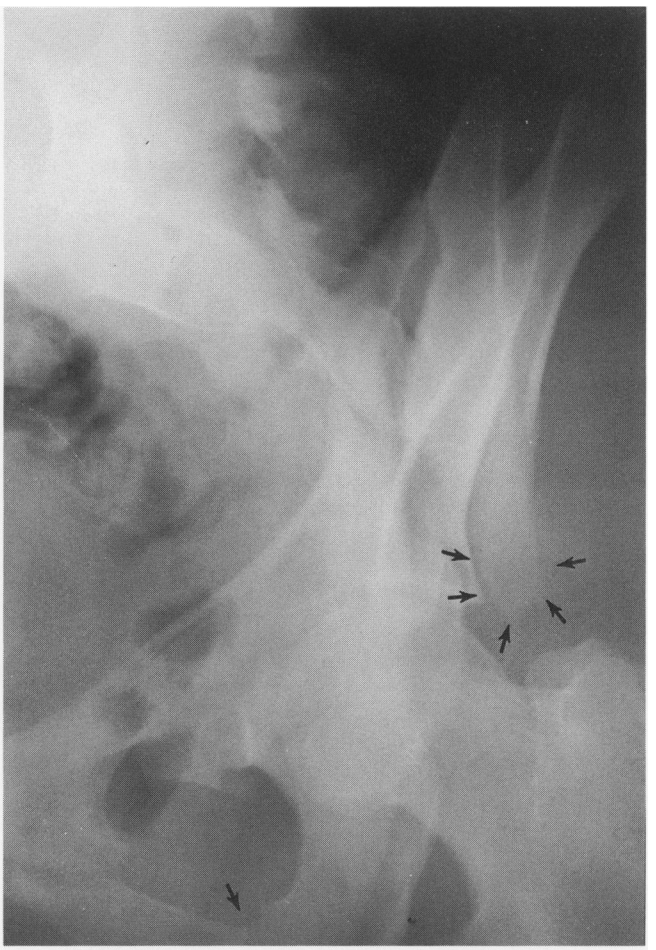

Figure 7a-f Radiographs and CT of a both column acetabular fracture.

Figure 7-a The AP pelvis demonstrates interruption of the II and IP lines (large black arrows). The fracture of the obturator ring and ilium are also seen (small black arrows) which occur together only with a BC fracture.

Figure 7-b The obturator oblique accentuates the obturator ring fracture. (small single arrow). This is an excellent example of a spur sign (multiple black arrows).

Column

Column fractures divide the acetabulum into front and back halves by fracture lines that are generally located in the coronal plane. There are five fracture types that demonstrate an underlying column fracture pattern; anterior column (AC), posterior column (PC), posterior column with posterior wall (PCPW), both column (BC) and anterior column-posterior hemitransverse (ACHT).

In fractures of the AC, a segment of the anterior acetabulum of variable size is fractured along with an anterior-superior segment of the innominate bone extending from the middle of the superior pubic ramus below to any point above as far back as the mid part of the iliac crest.[1] Radiographic hallmarks of most AC fractures include a fracture line extending above the acetabulum through the iliac wing and disruption of the IP line occasionally seen in several planes. Examine the proximal CT cut where this fracture line is well seen (Figure 7d).

On this CT cut the AC fracture will have a medial to lateral orientation indicating a coronal fracture line indicative of a column fracture pattern. *The presence or absence of this fracture rules in or out an AC fracture since none of the other acetabular fracture patterns create a fracture extending to the level of the sacro-iliac joint.* A low AC fracture is an exception to this rule. When the AC fracture is isolated, the IO will not show a posterior fracture line.

PC fractures must have a fracture of the obturator ring and disruption of the II line. The fracture into the obturator ring is best seen on the obturator oblique radiograph and on the low CT cut through the bottom of the acetabulum demonstrating a fracture of the quadrilateral plate (Figure 7f). The obturator ring fracture should involve the ischium or the inferior pubic ramus since the superior pubic ramus can be disrupted by an AC fracture. If it is an isolated PC fracture the OO will not demonstrate an anterior fracture line through the IP line, and the proximal CT cut will demonstrate the iliac wing to be

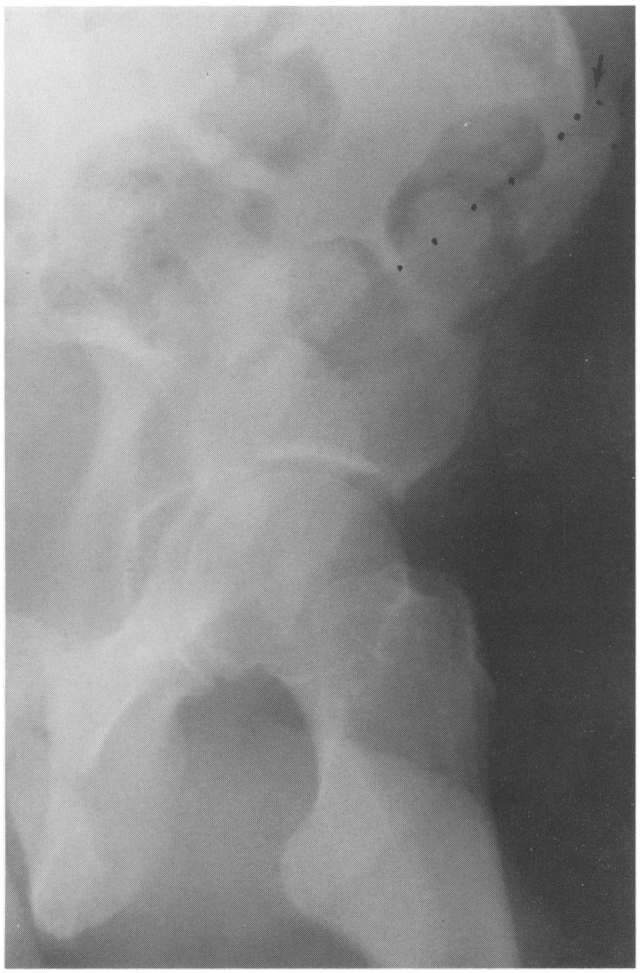

Figure 7-c The iliac oblique x-ray reveals a fracture of the iliac wing (black dots and arrow).

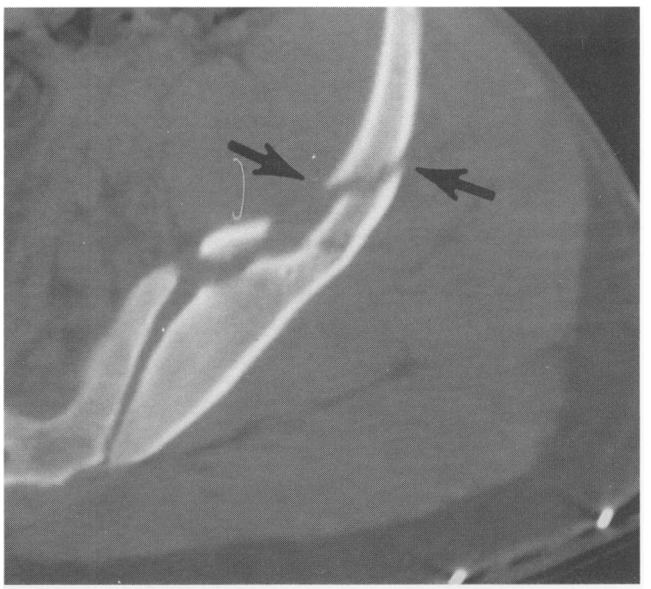

Figure 7-d A proximal CT cut demonstrates a fracture of the iliac wing (large black arrows).

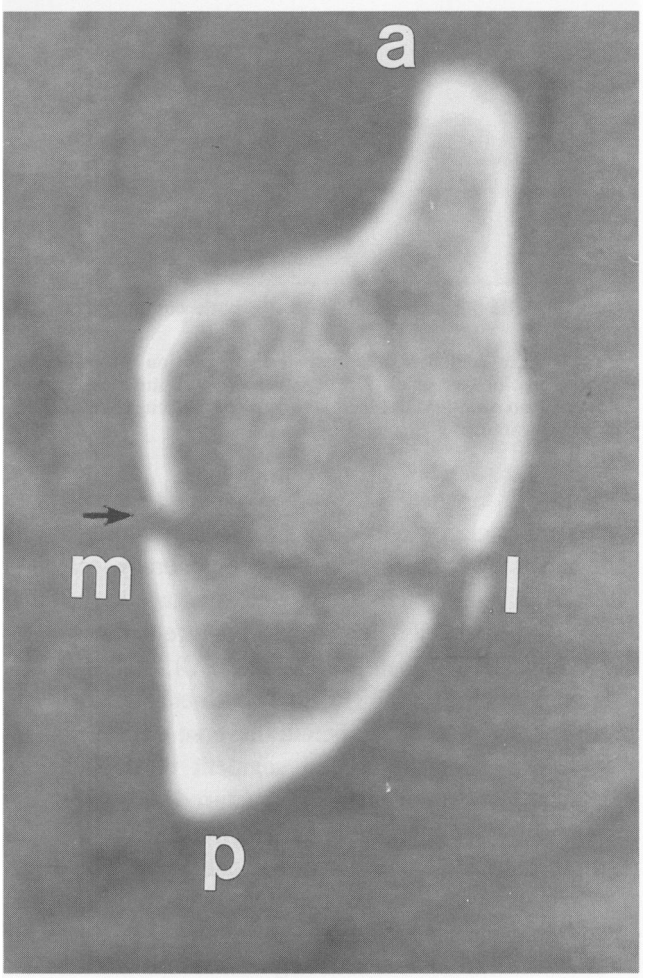

Figure 7-e More caudally, a fracture pattern typical of column fractures is seen traversing from medial to lateral through the weight bearing dome (small black arrow).

intact. Both AC and PC are coronal fracture patterns, so they will have medial -to- lateral major fracture lines on the CT scan.

The features of the BC fracture pattern deserve extra emphasis as this is a common fracture pattern and is initially difficult to interpret. It has the features of both an AC and PC fracture (Figure 7a,b,c,d,e,f). *This is the only fracture pattern with both an iliac wing fracture and a low break in the obturator ring.* Similar to a transverse pattern, both the II and IP lines will be disrupted (Figure 7a). The entire articular surface is separated from the intact iliac wing which is the iliac side of the sacro-iliac joint. For all other patterns a portion of the acetabular articular surface will remain with the nonfractured iliac wing. The pathognomic "spur sign" should be looked for laterally on the OO or CT (Figure 7b and 7f). This is the distal extension of the unfractured iliac wing which tapers to a spur. The CT scan will demonstrate a medial-lateral fracture pattern through the dome (Figure 7e). Since both columns rotate medially together with the femoral head, secondary radiographic

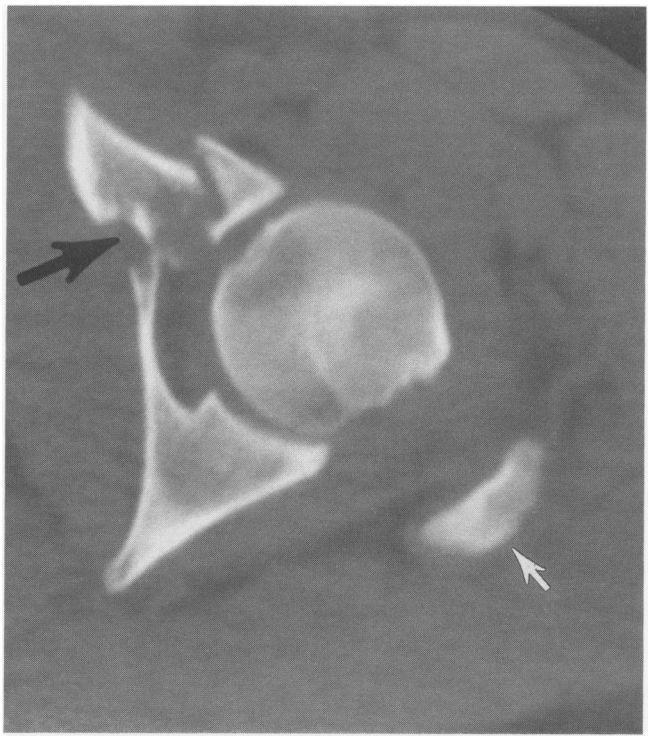

Figure 7-f The spike of iliac wing (the spur sign on the obturator oblique x-ray) is nicely seen on the CT scan at the joint level (white arrow). A fracture of the quadrilateral plate extending to the obturator ring is also seen (black arrow).

congruence will often be observed between the femoral head and acetabular fracture fragments despite the fracture displacement (Figure 7a,b,c).

III. The Systematic Approach

The following steps are designed to systematically evaluate acetabular fracture radiographs for the purpose of assigning each fracture to one of the ten groups. The initial goal is to classify the fracture into one of three major patterns: *column, transverse or wall.* Once these features have been recognized, then address the associated fractures (wall fractures or hemitransverse patterns.) These steps should be followed as outlined below.

Evaluate for a column fracture pattern in step 1 and 2, for a transverse pattern in step 3, and for a wall fracture in step 4. Combine these steps to classify the majority of the fractures accurately.

1) Is the iliac wing broken (obturator oblique, high CT scan)? yes: either AC or BC or ACHT. Be aware of a low AC fracture that could be missed on the CT at the level of the SI joint.
2) Is the obturator ring broken with breaks in the ischium or inferior pubic ramus (obturator oblique, CT through bottom of acetabulum)? yes: PC, BC or T - type (see # 3 regarding Transverse patterns). Beware that an AC fracture breaks the obturator ring at the superior pubic ramus only.
   >> If #1 and #2 are both yes, then BC is the only possible pattern (look for spur, no weight bearing dome with acetabulum, secondary congruence, and med-lat CT fracture pattern.)
   >> If #1 no and #2 yes, then PC or T-type is the diagnosis. Look at the obturator oblique and the CT cuts at the level of the dome and the mid-joint for an anterior fracture line; yes - T - type, no - PC.
   >> If #1 yes and #2 no, then AC or AC posterior hemi-transverse is the diagnosis. Look at the posterior column on the iliac oblique for a crossing posterior fracture line; yes - ACHT, no - AC.
3) Are the II and IP lines both broken with fractures exiting on the obliques both anteriorly and posteriorly? This indicates BC, ACHT or one of the three transverse variants.
   >> If #3 is yes: and #1 is no, must be one of the transverse patterns (rules out BC and ACHT); if #2 is yes, then must be a T-type: if #2 is no, then transverse only.
4) Is there a posterior wall fracture? (obturator oblique, CT through mid joint)
   >> If #4 is yes and if #1, 2, or 3 yes, then PW associated with above diagnosis if #'s 1, 2, and 3 no, then PW.

Application of the above four steps should be tested in the previous cases presented. Once you are familiar with these steps, try the unknown case presented in figures 8a-e.

SUMMARY

After a background understanding of the classification of Judet and Letournel and the radiographic anatomy of the pelvis, the majority of acetabular fractures are readily classified by utilizing the steps as outlined above. We feel that a systematic, stepwise approach to classifying acetabular fractures into larger groups and then subclassifying these groups will help simplify the application of the Letournel and Judet classification. Try using this method, and your ability to classify these fractures will improve.

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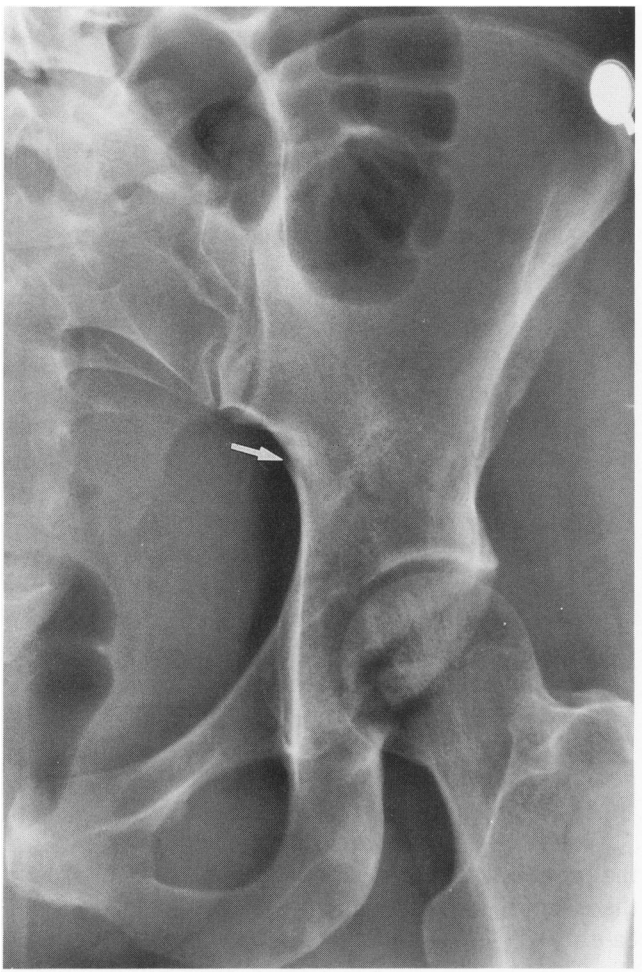

Figure 8a

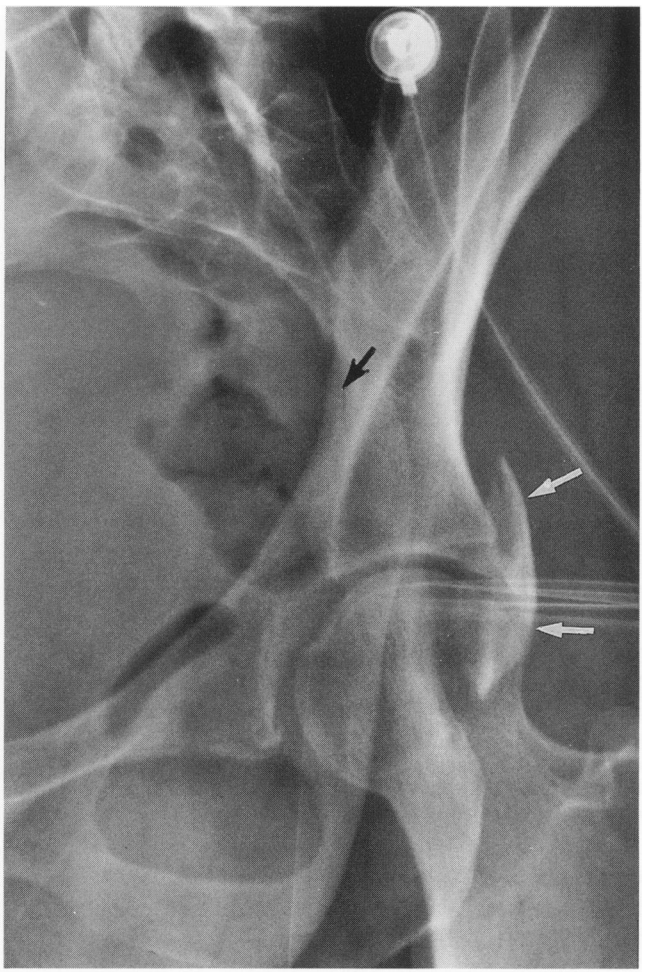

Figure 8b

Figure 8a-e Radiographs and CT scan of "unknown case".

Figure 8c

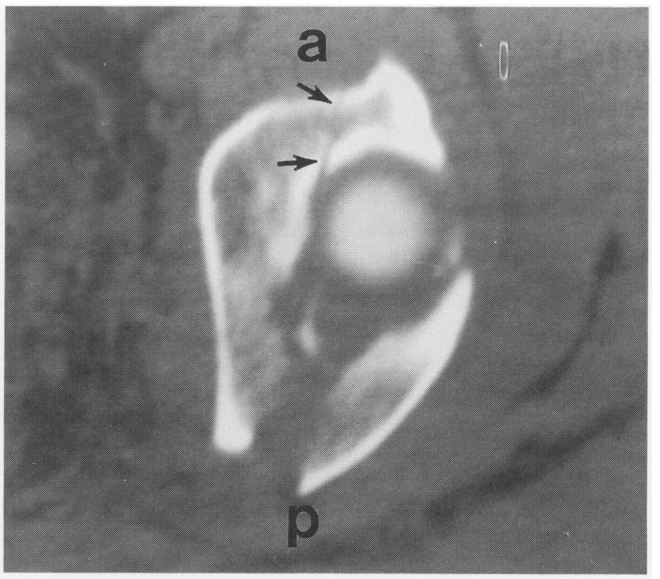

Figure 8d

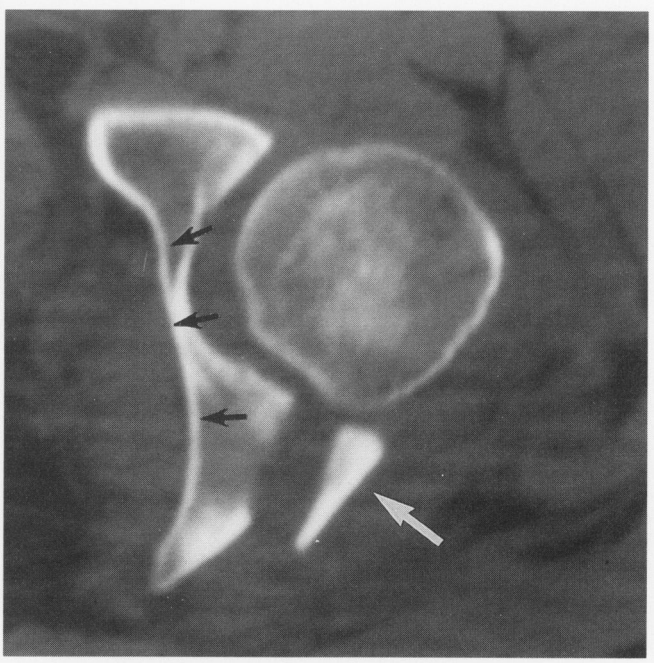

Figure 8e

LEGEND APPENDIX

Answer to unknown Figure 8a-e.

a) The AP pelvis shows a proximal fracture at the sciatic notch where the II and IP lines merge (white arrow).

b) The OO shows a PW fracture (white arrows) and a hint of an anterior fracture (black arrow). The obturator ring is not fractured.

c) The IO shows a posterior fracture line in the sciatic notch (black arrows).

d) The CT cut through the dome shows a displaced posterior fracture line and a nondisplaced anterior fracture line (black arrows).

e) The CT cut low through the acetabulum shows the bottom of the PW fracture (white arrow), and confirms that there is no break into the obturator ring (black arrow).

Systematic Approach

1) Is the iliac wing broken (would confirm on proximal CT cut)? - no
2) Is the obturator ring broken? - no
3) Are the II and IP lines both broken? - yes (check 8d)
4) Is there a PW fracture? - yes

Diagnosis

Transverse PW. The major fracture line posteriorly must go either into the obturator ring (PCPW) or anteriorly transverse PW.